

NOAA SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP)

PROJECT ANNUAL REPORT

PROJECT TITLE

Moving Forward: Adaptation and Resilience to Climate Change, Drought, and Water Demand in the Urbanizing Southwestern United States and Northern Mexico

INVESTIGATORS

(Research team and full contact information)

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April 1, 2009 – March 31, 2010

I. PRELIMINARY MATERIALS

A. Project Abstract

Spanning three inter-related research domains—regional climate and its impacts, urban water resources management, and stakeholder-based co-production of science and policy—and with a focus on the semi-arid, climatically vulnerable, and the Arizona-Sonora portion of the binational US-Mexico region, this project seeks to better understand (a) how to *institutionalize* the capacity of water managers and civil and emergency preparedness planners to use climate science and information to improve long-range and “adaptive” decisionmaking, (b) how to *regionalize* the efficient development and delivery of relevant and usable “climate outlook” products and services; and (c) how to increase, by integrating climate science into planning processes, the *resilience* of urban border communities to climatic and water-resources uncertainties.

Using the collaborative capacity of an experienced, multidisciplinary, and binational research team, our project targets our activities in four highly urbanizing “hotspots” within the region, namely Tucson, Arizona; the “twin” border cities of Nogales, Arizona, and Nogales, Sonora; Hermosillo, the capital of the state of Sonora; and the area surrounding the burgeoning coastal resort-town of Puerto Peñasco, Sonora. For each urban area, our approach involves five principal activities, to: (1) document and assess the community’s long-term, water-supply strategies; (2) assess the vulnerability to changes in supply and demand, and the uncertainty of future water supply plans, with particular focus on vulnerabilities at the urban-rural interface; (3) develop case studies to demonstrate opportunities for regionalized adaptive water-management planning; (4) develop, test, and refine a quarterly bilingual and binational climate outlook product with collaborating stakeholder groups; and (5) integrate and synthesize the findings and implications from each of the prior activities, develop final reports and products, and identify next steps for future research and applications activities.

Climate is the key unifying factor for selecting four urban growth hotspots within the monsoon-driven climate regime. The centerpiece of this two-part project (UA and UCAR/NCAR linked projects) is a binational climate outlook product to stimulate new stakeholder-informed climate knowledge to improve long-term, regional adaptive water management, analogous to the RISA products, such as the Western Water Assessment’s *Intermountain West Climate Summary* or CLIMAS’s *Southwest Climate Outlook*. The need for such a product has been articulated by two workshops, one in Hermosillo (January 2006) and at the Monsoon Regional Climate Applications workshop, also in 2006. An early version of this product has been developed by our research team and SMN (Mexico’s National Meteorological Service).

B. Research Objective

Key objectives of this project are to *institutionalize* effective use of climate information and climate science to promote adaptive water resources management in the long term; and to *regionalize* the production and dissemination of climate information and climate science in recognition of shared regional climate, economic interconnectedness, and similar rapid growth profiles in the Arizona-Sonora border region. Through iterative stakeholder workshops (four as of May 2010), this project aids the formation of formal and informal binational networks of climate scientists and social scientists, with water managers (federal, state, and local level), disaster relief officials, and climate agency officials (e.g., NOAA and Mexico's National Weather Service, SMN) to enhance reliance on climate information in current and future water planning. We are moving beyond the limited amount of regional climate information currently available to specific sectors including urban water managers, civil preparedness planners, and transboundary and regional water planners on both sides of the border to develop a technologically sophisticated binational climate product that relies upon state-of-the-art climate forecasts and models. Through the research team comprising UA, NCAR, NOAA, IMTA, COLSON, and in cooperation with SMN in Mexico, Tucson Water, and Arizona Department of Water Resources, we are refining, and field-testing a new, quarterly climate product thereby promoting sophisticated use and effective application of climate information. The binational climate outlook being developed builds upon the insights and input gathered in workshops with our collaborating stakeholders to incorporate essential features into the final product. Our team is providing training to collaborating stakeholders to facilitate sophisticated use and understanding of regional climate information. We also are building institutional capacity for utilizing climate science for water supply planning as well as new processes for regional cooperation and expertise-sharing on both sides of the border.

C. Approach

To complete the linked urban water management case studies for each of our four study sites, we have requested a one-year, no-cost extension on this project through June 30, 2011. At present, we have completed about 90% of the fieldwork and 70% of the case studies needed to achieve our stated goals. The methodological framework for the project was to: (a) document and assess long-term water supply strategies in the urban study sites; (b) conduct vulnerability assessments in the four urban study sites; (c) assess institutional and adaptive planning capacity in each of the sites; and (d) focus on the co-production of climatic information for use in the binational climate outlook product to influence regional adaptive water management. The data gathered in the first phase of the research is the basis for four case studies being developed in this project, including for Tucson-Hermosillo; Ambos Nogales; and Puerto Peñasco. We have nearly completed Phase I of our research (Activities 1-4) using three principal methods: database construction, semi-structured intensive interviews, and stakeholder workshops. We gathered census data and government economic data to construct a database to analyze demographic and economic trends and determine potential impact on climate vulnerability. We have conducted semi-structured interviews with water managers, preparedness planners, urban and rural water users, and other stakeholders to identify institutional changes, to identify water management and augmentation planning practices, to ascertain costs associated with recent drought in the region, to identify available sources of climate information and science, and to identify principal elements of vulnerability in the four urban areas. We have conducted four binational research team meetings to stay on-track with project goals and advance the workplan. Lastly, we have conducted three stakeholder workshops (and one project launch workshop) to determine key challenges to achieving goals in 5-, 10-, and 20-year scenarios, to develop institutional maps for climate information flows, to identify available climate information and sources, and to identify adaptive management strategy to meet key challenges. The fourth stakeholder workshop is planned for May 7, 2010, in Hermosillo (60 participants registered). In the stakeholder workshops, we field-test the binational climate outlook prototype, administer a written evaluation survey, and discuss primary areas of vulnerability in terms of short-to-long term water supply and plans for adaptive management. We have facilitated a discussion of how to institutionalize the use of the binational climate outlook product in standard long-term planning and current operations of water management and civil preparedness agencies.

Phase I of the project centered on data collection, construction of a database, conducting fieldwork at specific sites, including intensive semi-structured interviews with key stakeholders and meetings with institutional representatives. Phase II of the project (beginning May 2010) will focus on (a) completion of the case studies and development into a final project report (by Sept. 2010); (b) a wrap-up stakeholder workshop to present case study findings and solicit feedback and input; (c) a binational research team meeting (held in conjunction with the workshop) to discuss future initiatives on identified priorities; (d) submission of the case studies as a special journal issue in a peer-reviewed journal; and (e) publication of the case studies as a book in Spanish (from a Sonora, Mexico press). The case studies include compilation and synthesis of basic socioeconomic and demographic data; assessment of the effectiveness of long-term water supply strategies in the study region; and identification of specific institutional risk factors leading to increased vulnerability to climate-induced water resources variability on the part of urban and coastal area water and emergency managers. In Phase II of the project, based on the draft case studies, we will work with the engaged stakeholder groups to assess opportunities for

regionalized adaptive water management, and where applicable, initiate binational, inter-institutional links towards robust and responsive water management strategies and systems, and assess the utility and effectiveness of the binational climate outlook product to support binational adaptive water management strategies.

The key beneficiaries of the project findings are decision-makers in southern Arizona and northwest Mexico including federal, state and municipal water managers and agencies and emergency preparedness and disaster planning professionals, as well as the climate and water research community itself. The general public will also benefit through our sustained collaboration with real-world decision-makers and water managers to be better able to meet society's future water supply needs, particularly in the four major urban areas targeted in our study. Additionally, the scientific community will benefit from our project's results in innovative, transboundary processes for engaging a diverse set of stakeholder groups to work on institutional innovations in the utilization of climate science, and in the development of a prototype model for co-production of stakeholder-informed science. NOAA will benefit by advancing new ways to institutionalize climate information and science in long-term planning, mitigation, and adaptation strategies.

D. Description of any matching funds/activities used in this project

ESTIMATED TOTAL LEVERAGED AMOUNT: \$250,000

Inter-American Institute for Global Change Research (# SGP HD 005 (2007-2009).

INFORMATION FLOWS AND POLICY: Use of Climate Diagnostics and Cyclone Prediction for Adaptive Water-Resources Management Under Climatic Uncertainty in Western North America. Amount: \$147,300 (9/07-8/09) National Oceanic and Atmospheric Administration (NOAA)—Regional Integrated Science Assessment (RISA) Program. Integrating Climate Science for Decision-Support, Mitigating Risk and Promoting Resilience. PI: Jonathan Overpeck. Leveraged Amount: approx. \$100,000 from 2008-2010, plus \$50,000 during 2010-2011 (requested no-cost extension). 2007-12.

See related leveraging list in last section of this report.

II. ACCOMPLISHMENTS

A. Project timeline and tasks accomplished.

April 1-June 30, 2009

Continued interviews with stakeholder in four field study sites
Wrote team-authored article on adaptation in a transboundary context, now accepted for Publication in a special issue on climate change (see Wilder et al., forthcoming 2010)
Made preparations with IAI and collaborative partners at the Mexican Institute for Water Technology for July workshop
Made plans for summer workplan and development of case studies

July 1, 2009-August 31, 2009

During this period, case study development continued.
Following a first stakeholder workshop in November, 2008 (Hermosillo), a second stakeholder workshop was held in July 2009 in conjunction with a binational research team meeting to advance our workplan and assess progress.

July 22, 2009: 2nd Stakeholder Workshop— Mexican Institute for Water Technology (IMTA), Jiutepec, Morelos, Mexico

Attendance: 50 people, including National Commission on Water (CONAGUA) officials, Mexico's National Weather Service (SMN) officials, IMTA water researchers, climatologists from the Universidad Nacional Autónoma de Mexico, researchers from University of Arizona, CIBNOR

Highlights: national-level stakeholders' engagement with water-climate information flows in the U.S.-Mexico border region; presentations by two deputy directors (Dr. M. Rosegaus and Dr. V. Davydova) of Mexico's National Weather Service (SMN), researchers at the national Mexican Institute of Water Technology (IMTA) (Dr. J. Aparicio, Dr. R. Lobato, Dr. M. Montero), and others

Accomplishments: We garnered perspectives from decision-makers, water managers, and climate professionals at the national level regarding urban water management and opportunities to improve adaptive capacity for Mexico's Northwest region. We gathered data via plenary discussion, breakout groups and surveys regarding the major water-related vulnerabilities of Mexico's Northwest region. We solicited and received diagnostic feedback on climate information flows in the existing institutional structure and improvements needed.

September—October, 2009

The 3rd Stakeholder Workshop was held in Puerto Peñasco.

October 2, 2009: 3rd Stakeholder Workshop—Puerto Peñasco, Sonora, Mexico

Attendance: 75 people, including Mexico's National Weather Service (SMN, Mexico D.F.), State of Baja California (MX) Department of Environmental Management and State Climate Action Plan, National Center for Atmospheric Research (U.S.), municipal water managers, climatologists, researchers, students

Highlights: presentations on climate and coastal/urban water sector vulnerability and adaptive planning by the deputy director of Mexico's National Weather Service (SMN) on climate information for the U.S.-Mexico border region; by the director of the Department of

Environmental Management for the State of Baja California (MX) on the State Climate Action Plan (PEAC) (Dr. E. Nieblas); by the new Northwest Regional director of the National Water Commission (Ing. F. Diaz); and by a research scientist at the National Center for Atmospheric Research and member of our research team (Dr. P. Romero-Lankao).

Accomplishments: focused on climate-related vulnerability in coastal areas and in urban areas, including extreme storm events, flooding, drought and water supply; discussed challenges of future water supply augmentation strategies, such as desalination, in context of climate change; gathered online survey data from workshop participants regarding climate information needs and water-related vulnerabilities in our identified study sites

Binational research team retreat: one-day meeting in Pto. Peñasco to finalize outline of case study report; develop plans for publication of case studies in a special issue of a peer-reviewed journal (in English) and as a book in a Sonoran press series (in Spanish)

Resumed fieldwork on vulnerability and water management in Tucson, Hermosillo, Puerto Peñasco & Nogales, AZ and Nogales, Sonora

Special briefing on October 22, 2009 of Hermosillo's Mayor Javier Gándara Magaña regarding climate change and its potential impacts on Hermosillo water supply, and potential solutions (Garfin/Pineda).

November 2009—March 2010

Total of 37 publications published or accepted in peer-reviewed journals or books generated by research team members funded by SARP in 2009 and 2010 (to date). These include two edited books by SARP team members (Varady; Scott). SARP research team (Wilder/Scott et al.) have border research article accepted for publication in special issue of geography journal, *Annals*, on climate change.

Presentations (selected) of SARP-related research at multiple conferences, including: international Earth Systems Governance Conference (M. Wilder), 11/23-25/2009; Puentes Consortium, Houston (R. Varady), 1/14/10; 5 papers presented at Amer. Geographers' conference (Garfin, McEvoy, Morehouse, Scott, Wilder) 4/13-17/10; International Drought Symposium, Riverside CA (G.Garfin), 3/24-26/2010.

Finalized plans for May 7, 2010, 4th Stakeholder Workshop in Hermosillo, Sonora, with key stakeholders from Tucson Water, Arizona Department of Water Resources, and Central Arizona Project oversight board as speakers, as well as Mexican counterpart officials from Agua de Hermosillo, State Water Commission (CEA), National Water Commission (CONAGUA).

Two additional graduate research assistants hired at .25 FTE each to conduct fieldwork and development Binational Climate Summary (1/2010)

Fieldwork on vulnerability and development of case studies continued in all 4 sites. Fieldwork accomplishments: completed a total of 60 fieldwork trips (Tucson, Az, Nogales, Az, Nogales, Son., Hermosillo, Son., Puerto Peñasco, Son.), conducted 85 interviews (with a range of local and regional decisionmakers, NGOs, and residents), 2 focus groups and 4 days of participant observation with water trucks, attended 20 community and binational meetings (including the Arizona-Mexico Commission Water Committee, EPA's Border 2012; BECC Task Forces, and others), and completion of 4 stakeholder workshops. This fieldwork has resulted in solid contacts

with local decisionmakers and NGOs, detailed data on municipal water use and water supply networks, information on proposals to improve, augment, or conserve the region's water supply, along with detailed ethnographic data on water supply vulnerability in *colonias*. Research assistants have also contributed to the publication and translation of the Border Climate Summary (BCS) and the production of bi-lingual webinars.

Case study drafts are written and submitted to project PI's for editing and review.

Publication of two Binational Climate Summaries in this reporting period (February and April 2010)

Over the course of the year, to date, SARP travel funds have supported travel by 8 researchers to present project-based papers at domestic (e.g., Association of American Geographers) and international meetings, including the IHDP's Earth Systems Governance meeting (Amsterdam 09); the IAI-NCAR meeting (Costa Rica-10); the Mexican water research network meeting (Cuernavaca 10). In addition, travel funds have supported the fieldwork in study sites and researchers and speakers to attend the binational workshops.

Forthcoming plans

Stakeholder Workshop planned for May 7, 2010 (Hermosillo)

North American Monsoon web-based videobriefing (bilingual) planned for May 24, 2010

Please note: Accomplishments of colleagues at NCAR are listed in a separate annual project report submitted by Dr. David Gochis

B. Summary of findings

A. Binational Climate Summary/Resumen del Clima de la Frontera (BCS/RCF)

Need for temporally and spatially specific climate information, forecasts, and products that address sub-regional levels and micro-climates within region is the key to improved utilization of such information by water managers, disaster relief planners, and other stakeholders.

Publication in Spanish is key for utilization by stakeholders in Mexico, and thus the bilingual focus (English/Spanish) of the BCS/RCF is essential.

Stakeholders are willing to engage with various BCS/RCF formats, including the current hard copy and internet-based newsletter format, as well as regional video-briefings and other formats.

Development of the BCS/RCF and sustained interaction at Cuernavaca and Peñasco workshops facilitated the creation of a new Memorandum of Understanding for future collaborations between the NOAA Office of Hydrology and Mexico's National Water Commission (CONAGUA) and National Weather Service (SMN).

B. Vulnerability Assessments

Arizona-Sonora study sites exhibit distinct, yet overlapping, characteristics of water-climate related vulnerability, associated with population growth and economic development (e.g., Tucson and Hermosillo); changing economy and lack of adequate urban planning and resources (e.g., Nogales, Sonora); and environmental vulnerability related to climate variability on the Gulf of California coast and the fragile coastal ecosystem and estuaries (Pto. Peñasco).

Augmentation strategies based on development of new desalination plants in both Arizona and Sonora can reduce some vulnerabilities (e.g., future water supply) while potentially increasing other vulnerabilities (e.g., equity and affordability of water; environmental).

Factors that contribute to vulnerability in Tucson and southeast Arizona include: lack of new sources of water supply to supplement existing sources; the near-exhaustion of conventional conservation strategies (Tucson) and need to develop innovative yet feasible water reuse plans; urban-agriculture conflicts over future water supply; and challenges in identifying politically and economically feasible adaptive management alternatives.

Factors that contribute to vulnerability in Hermosillo and northwest Sonora: insufficient institutional frameworks and lack of planning for climate-related reduction of vulnerability; lack of financial resources; continued centralized control of water management and financial authority; centralized generation of climate information; larger concentration of marginalized populations and incidence of poverty (than on Arizona side) creates different vulnerability characteristics.

C. Institutional Capacity and Adaptive Management

The emerging recommendations on enhancing adaptive capacity cluster into four principal areas:

First, the need and utility of forecasts and climate information products must be clearly identified, and prioritized, and steps should be taken to fill existing gaps. Climate information and forecasts that is specific at sub-regional level is highly desired by stakeholders.

Second, distributing information is not sufficient for its effective utilization; improved understanding of information flows is essential for policy and adaptive response to climate and water uncertainty. Communication of alerts and warnings must be tailored to appropriate and available technologies (e.g., radio v. internet) and in the appropriate language.

Third, to be effective, programmatic responses must be built on existing agencies' mandates with careful consideration of how such initiatives will be institutionalized, including the need for new organizational forms.

Climate information and forecast products in Spanish are much more limited than in English; thus, newsletters and webinars that are available in Spanish serve an identified need.

Finally, evaluation and follow-up of adaptive responses are essential; in other words, an evolutionary approach is required that continues to refine information flows, adaptation, and outcomes. Continued formation of informal and formal networks of climate scientists, social scientists and stakeholders within the region will help facilitate this goal of sustained interactions around a goal-based theme.

C. Reports, papers, publications or presentations arising from this project

Please refer to outputs list below. Note: Publications in dark print refer to this reporting period (2009-2010). Publications in light print are from previous reporting periods.

PUBLICATIONS

2010

Forthcoming

Akhter, M., K.J. Ormerod, **C.A. Scott**. Forthcoming. Resilience and urban planning: Water in Tucson, Arizona. *Critical Planning*.

Coles, R., C.A. Scott, G.M. Garfin. Forthcoming. Communicating risk and vulnerability: Weather, climate, and water on the U.S.-Mexico border. NOAA Climate Program Office, *white paper solicitation*.

Milman, A.**C.A. Scott**. Forthcoming 2010. Beneath the surface: intra-national institutions and management of the United States – Mexico transboundary Santa Cruz aquifer.

Salazar, Alejandro and **Nicolás Pineda**. Forthcoming 2010. “Escenarios de Demanda y Políticas para la administración del agua en la ciudad de Hermosillo, Sonora.” *Región y Sociedad*. El Colegio de Sonora.

Scott, C.A. Forthcoming 2010. “Groundwater.” *Encyclopedia of Geography* (invited contribution). Thousand Oaks, CA: SAGE Publications.

Scott, C.A., S. Megdal, L.A.Oroz., M. Mexía, H. Ramos. Forthcoming 2010. Building shared vision: assessment of transboundary aquifers along the United States – Mexico border. In Proceedings of *International Conference on Water Scarcity, Global Changes, and Groundwater Management Responses*, University of California – Irvine, UNESCO, USGS, Irvine, CA, 1-5 Dec.

Wilder, M. C.A. Scott, R. Varady, N. Pineda, G.M. Garfin, and J. McEvoy. Adapting Across Boundaries: Knowledge, Social Learning and Resilience in the U.S.-Mexico Border Region (forthcoming October 2010). *Annals of the Association of American Geographers*.

Wilder, M. forthcoming 2010. Promises Under Construction: The Evolving Paradigm for Water Governance and the Case of Northern Mexico, in Alberto Garrido and Helen Ingram, eds., *Water, Food, and Sustainability*. London: Routledge.

Wilder, M. and Gregg M. Garfin, forthcoming 2010. Drought Risk and Hazard, in B. Warf (ed.) *Sage Encyclopedia of Geography*. Los Angeles/London: Sage Publications.

In print

2010

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Coles, A.R., C.A. Scott, and G.M. Garfin. 2009. Weather, climate, and water: An assessment of risk, vulnerability, and communication on the U.S.-Mexico border. In Proceedings of *The Annual Meeting of the American Meteorological Society*. Phoenix, AZ. 11-15 Jan. http://ams.confex.com/ams/89annual/techprogram/paper_149938.htm

Diaz-Caravantes, R.E. and C.A. Scott. 2009. Water management and biodiversity conservation interface in Mexico: A geographical analysis. *Applied Geography*. doi:10.1016/j.apgeog.2009.10.003.

Farfán, L.M. 2009. Ciclones tropicales en el Pacífico oriental. *Resumen del Clima de la Frontera*, University of Arizona, Oct. (Tropical cyclones in the eastern Pacific. *Border Climate Summary*, University of Arizona, Oct.) http://www.climas.arizona.edu/forecast/ResumendelClimadelaFrontera_Oct08.pdf http://www.climas.arizona.edu/forecasts/BorderClimateSummary_Oct08.pdf

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Garfin, G. 2009. Dry heat: An overview of climate changes and their impacts on North America's arid regions. *Sonárida 27*, Enero-Junio, Hermosillo, Sonora, Mexico. <http://www.iesa.gob.mx/sonarida/default.htm>.

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Scott, C.A. 2008. Building shared vision: Assessment of transboundary aquifers along the United States – Mexico border. International Conference on Water Scarcity, Global Changes, and Groundwater: Management Responses. University of California – Irvine, UNESCO, USGS, 1-5 Dec.

Scott, C.A. 2008. Groundwater rights in Mexican agriculture: Spatial distribution and social and economic determinants. Association of American Geographers Annual Meeting. Boston, MA 19 Apr.

Scott, C. A., R. G. Varady, G. Garfin, M. Wilder, N. Pineda, and M. Montero. 2008. Organizers. Stakeholder workshop on Information flows and policy: Use of climate diagnostics and cyclone prediction for adaptive water-resources management under climatic uncertainty in western North America. Inter-American Institute for Global Change Research. Hermosillo, Sonora, Mexico. 7 Nov.

Scott, C.A., 2008. Adaptive water resources management under climatic uncertainty in western North America (and member of workshop organizing committee). Regional Climate Forum for Northwest Mexico and the Southwest United States. Centro de Investigación Científica y de Educación Superior de Ensenada and NOAA, Ensenada, Baja California, Mexico. 10-11 Apr.

Scott, C.A. 2007. Energy boom and groundwater bust: Mexico's water-energy nexus with implications for the U.S. border region. First Western Forum on Energy and Water Sustainability, Bren School of Environmental Science & Management, Univ. of California, Santa Barbara, CA. 22 Mar.

Scott, C.A., 2007. The water-energy nexus in Mexico: Groundwater sustainability along the border with the United States. Hydrology & Water Resources Departmental Seminar Series, University of Arizona. Tucson, AZ. 21 Feb.

Scott, C.A. 2007. Water and energy management challenges on the Arizona-Mexico border. Southwest Hydrology and Arizona Hydrological Society Regional Water Symposium. Tucson, AZ. 31 Aug.

Scott, C.A., Session chair: Coupled water and energy demand in the Southwest and U.S.-Mexico border region. Southwest Hydrology and Arizona Hydrological Society Regional Water Symposium. Tucson, AZ. 31 Aug.

Varady, R.G. C.A. Scott, M. Wilder, and G. M. Garfin. 2010. Integrated Climate and Water Resources Assessment for Adaptive Management in Western North America. To be presented at AGU Conference of the Americas. Iguazu, Brazil. 8-13 Aug. 2010.

Varady, R. G. 2010. Global water governance: Confronting aridity, climate change, and transboundary conflict. Presented as part of Roy F. Weston Distinguished Global Sustainability Lecture Series, "Balancing Global Water Demands for Food, Sanitation, Energy, and Ecosystems." Center for Sustainability and the Global Environment, Gaylord Nelson Institute for Environmental Studies, University of Wisconsin-Madison. 29 Apr. (invited).

Varady, R. G. 2010. Environmental change and institutions in the U.S.-Mexico border region. Presented at UC MEXUS Colloquium, "Perspectives on the U.S.-Mexico Border Wall." Riverside, CA. 22 Feb. (invited).

Varady, R. G., I. Aguilar Barajas, and G. Mejía Velázquez. 2010. Environment and security in the U.S.-Mexico border region: Water and air issues. Presented at the Puentes Consortium Mexico-U.S. Higher Education Leadership Forum. Houston, TX. 14 Jan. (invited).

Varady, R. G., R. Salmón Castelo, and S. Eden. 2009. Key issues, institutions, and strategies for managing transboundary water resources in the Arizona-Mexico border region. Presented at “Arizona-Israeli-Palestinian Water Management and Policy Workshop: Economic, Environmental, and Community Implications of Expanding Reuse and Desalination for Future Water Supplies.” Tucson, AZ. 1 Sept.

Varady, R. G., M. Wilder, C. A. Scott, N. Pineda, B J. Morehouse, and G. Garfin. 2009. Institutions and societal impacts of climate in the Arizona-Sonora portion of the U.S.-Mexico border region. Presented (by M. Wilder) at Open Meeting of the International Human Dimensions Program (IHDP). Bonn, Germany. 26-30 Apr.

Varady, R. G., M. Wilder, C. A. Scott, G. Garfin, N. Pineda, B. Morehouse, A. Coles, J. McEvoy, K. Sammler. 2009. Climate, society, and information flows in the U.S.-Mexico border region. Poster presented at the International Alliance of Research Universities: International Scientific Congress on Climate Change. Copenhagen, Denmark. 10-12 Mar.

Varady, R. G. 2009. Information flows and policy: Use of climate diagnostics and cyclone prediction for adaptive water-resources management under climatic uncertainty in western North America. Presented at Joint Principal Investigators’ Meeting of the Inter-American Institute for Global Change Research (IAI). Montevideo, Uruguay. 24 June.

Varady, R. G. 2009. Navigating institutional challenges to cross-border climate research. Presented at International Workshop for CHANGE (Climate and Hydrology Academic Network for Governance and the Environment). Mexico City, D.F., Mexico. 5 Mar. (invited).

Varady, R.G. 2009. Member of panel on: Challenges posed by climate change and drought and their impacts on water availability and society in North America. Workshop on Climate-Related Water Constraints and Their Implications for Relations Across North American Boundaries. México City, D.F., Mexico. 5-6 Mar.

Varady, R.G. 2008. Water in the U.S.-Mexico border region: A look at hotspots. Presented at Colloquium at North-West University. Gauteng, South Africa. 29 April. Also presented at Séminaire Interdisciplinaire sur le Développement Durable (SIDD). Lille, France. 18 Sept.

Varady, R. G. 2008. Information flows and policy: Use of climate diagnostics and cyclone prediction for adaptive water-resources management under climatic uncertainty in western North America. Presented at Joint Principal Investigators’ Meeting of the Inter-American Institute for Global Change Research (IAI). Panama City, Panama. 21 Feb.

Varady, R.G., G. Garfin, B. Morehouse, and M. Wilder. 2007. Institutions and societal impacts of climate in the Lower Colorado and San Pedro Basins of the U.S.-Mexico Border region. Presented at AGU Joint Assembly. Acapulco, Mexico. 25 May.

Wilder, M. Governance of the Colorado Delta. 2010. Towards a Sustainable 21st Century conference, University of California, Irvine. 14 May. Invited speaker.

Wilder, M., C. A. Scott, N. Pineda Pablos, R. G. Varady, G. Garfin, and J. McEvoy. 2010. Vulnerability and Adaptation in a Transboundary Context: Binational Approaches to Assessing Urban Vulnerability and Adaptation in the U.S.-Mexico Border Region. Association of American Geographers Annual Meeting, Washington, D.C. 16 April, 2010.

Wilder, M. (Session Organizer). 2010. El Agua en las Regiones Fronterizas: gestion y politica. Primer Congreso, Red de Investigadores de Ciencias Sociales acerca del Agua (ISSA), Mexican Institute of Water Technology, Jiutepec, Morelos, 19 March.

Wilder, M., C. A. Scott, N. Pineda Pablos, R. G. Varady, G. Garfin, and J. McEvoy. 2010. Adaptando al Cambio Climatico: El Agua y la Vulnerabilidad Urbana and la Frontera Mexico-EEUU. Primer

Congreso, Red de Investigadores de Ciencias Sociales acerca del Agua (ISSA), Mexican Institute of Water Technology, Jiutepec, Morelos, 19 March.

Wilder, M., C. A. Scott, N. Pineda Pablos, R. G. Varady, G. Garfin, and J. McEvoy, 2009. Adapting across boundaries: Knowledge, social learning and resilience in the US-Mexico border region. Paper presented at Earth Systems Governance Conference. Amsterdam, Netherlands. 3 Dec.

Wilder, M. with **R. Díaz**. 2009. Communities, conservation and climate change: New geographies of climate change governance in the binational Colorado Delta Region (juried selection of papers). Presented at the International Human Dimensions of Global Change (IHDP) Open Meeting. Bonn, Germany. 26-30 Apr.

Wilder, M. with **R. Díaz**. 2009. Water, cities, and peri-urban vulnerabilities in Northwest Mexico. Association of the American Geographers Annual Meeting. Las Vegas, NV. 22-27 Mar.

Wilder, M. 2008. Una sobre-vida de los proyectos NOAA-SARP y CLIMAS. Inter-American Institute on Global Change Research (IAI) Stakeholders' Workshop. Universidad de Sonora. Hermosillo, Sonora, Mexico. 7 Nov.

Wilder, M. 2008. Sobre agua, ciudades y gestión adaptiva. Inter-American Institute on Global Change Research (IAI) Stakeholders' Workshop. Universidad de Sonora. Hermosillo, Sonora, Mexico. 7 Nov.

Wilder, M. 2008. Overview of NOAA-SARP and CLIMAS projects on water, cities, and adaptive management. Institute for the Study of Planet Earth and Udall Center for Studies in Public Policy, University of Arizona. Tucson, AZ. 26 Sept.

Wilder, M. 2008. Political and economic apertures: The shifting state-society relationship and national water policy transition in Mexico. Invited paper for International Water Transitions workshop, University of Amsterdam. Amsterdam, The Netherlands. 3-4 July.

Wilder, M. 2008. Promises under construction: The evolving water governance paradigm and the case of northern Mexico. Invited participant at the Rosenberg International Forum for Water Policy. Zaragoza, Spain, 23-28 June.

Wilder, M. 2008. How does the public fit in? Climate change, adaptation and social stakeholders in the Southwest US and Northwest Mexico. Guest lecture, Department of Political Science, University of Redlands. Redlands, CA. 16 May.

Wilder, M. 2008. New geographies of environmental governance: Communities, conservation and climate change in the Colorado Delta and border region. Spaces and Society Lecture Series, Department of Political Science, University of Redlands. Redlands, CA. 15 May.

Wilder, M. 2008. New geographies of environmental governance: Communities, conservation and climate change in the Colorado Delta and border region. Association of the American Geographers Annual Meeting. Boston, MA. 17 April.

Wilder, M. 2008. The environment for water: 21st-Century transitions in Mexican water policy and implications for Sonora. Rocky Mountain Council on Latin American Studies (RMCLAS) 2008 Meeting. Flagstaff, AZ. 11 Apr.

Wilder, M. 2008. Transboundary water: Problems and challenges. Presented to Mexican Migration Scholarship Meeting, Consortium of North American Higher Education (CONAHEC), University of Arizona. Tucson, AZ. 9 Apr.

Wilder, M. 2008. Water governance in Mexico. Presented to the International Water History Association (IWhA) Board. Tucson, AZ. 19 Mar.

Wilder, M. 2008. Communities, conservation, and climate change: New geographies of environmental governance in the binational Colorado Delta Region. Department of Geography and Regional Development Colloquium, University of Arizona. Tucson, AZ. Feb.

Wilder, M., R.G. Varady, N. Pineda, A. Browning-Aiken, R. Díaz, and G. Garfin. 2007. New water management institutions in Mexico's 'new culture of water': Emerging opportunities and challenges for effective use of climate knowledge and climate science. Presented at AGU Joint Assembly. Acapulco, Mexico. 23 May.

D. Discussion of any significant deviations from proposed workplan (e.g., shift in priorities following consultation with program manager, delayed fieldwork due to late arrival of funds, obstacles encountered during the course of the project that have impacted outcome delivery). (Limit to one paragraph)

We have not deviated significantly from the proposed objectives or priorities in this project. However, we have requested a one-year no-cost extension in order to complete the urban water management case studies, sponsor a wrap-up stakeholder workshop to solicit feedback and plan future collaborations, and develop publications [i.e., special journal issue (English) in peer-reviewed journal; book publication from a Sonoran press (Spanish).]

E. Where appropriate, describe the climate information products and forecasts considered in your project (both NOAA and non-NOAA); identify any specific feedback on the NOAA products that might be helpful for improvement. (bulleted response)

- NOAA-CPC, NOAA-NWS, and IRI (NOAA-funded) make up 19%, 14%, and 7%, respectively, or a total of 40% of sources of climate information for Sonora resource management stakeholders.
- Eighty-eight (88)% of survey respondents (n=34) desired more climate and hydrologic information from the United States.
- The Binational Climate Summary relies on NOAA temperature and precipitation data, and analyses to which NOAA contributes, including the U.S. Drought Monitor and the North American Monsoon Experiment Forecast Forum. We have not gathered specific feedback on these products.
- The NOAA-NWS Tucson Forecast Office contributed a forecast presentation to our May 2009 binational videobriefing.

IV. WEBSITE ADDRESS FOR FURTHER INFORMATION (IF APPLICABLE)

<http://udallcenter.arizona.edu/sarp/>

V. ADDITIONAL RELEVANT INFORMATION NOT COVERED UNDER THE ABOVE CATEGORIES.

The research team has built synergies with the following leveraged awards:

2002-07. Variability, social vulnerability, and public policy in the southwestern United States (Climate Assessment of the Southwest, CLIMAS). (J. Overpeck, Institute for the Study of Planet Earth, PI M. Wilder, Co-PI, National Oceanic and Atmospheric Administration (NOAA)). University of Arizona. Tucson, AZ. Total award amount: \$5,910,447. Wilder percentage: 8.37 %

2003-06. Use of Climate-Information Products by Water Managers and Other Stakeholders in Two GCIP/GAPP Watersheds in Arizona/Sonora and Oklahoma. (R. Varady, PI, M. Wilder, Co-PI, National Oceanic and Atmospheric Association (NOAA) Office of Global Programs (OGP), 2003-2006). Total award: \$236,000. Wilder amount: \$44,217.

2007-12. CLIMAS Integrating climate science for decision-support, mitigating risk and promoting resilience: Climate assessment for the southwest. NOAA Climate Program Office (\$4,000,000 over 5 years). (J. Overpeck - PI; G. Garfin, M. Wilder, B. Morehouse – co-PIs). NOAA Climate Program Office.

2007-09. Information flows and policy: Use of climate diagnostics and cyclone prediction for adaptive water-resources management under climatic uncertainty in western North America (R. Varady – PI; C.A. Scott – deputy-PI; G.M. Garfin, N. Pineda, M. Montero – co-PIs). \$147,286, Inter-American Institute for Global Change Research.

2007-08. Geospatial analysis of urban thermal gradients: Application to Tucson, Arizona's projected water demand (C.A. Scott – PI; S. Yool, A. Comrie – co-PIs). \$12,000. United States Geological Survey 104B administered by University of Arizona Water Resources Research Center.

2007. Coupled water and energy demand in the Arizona-Sonora border region: Groundwater pumping, municipal water services, and electrical power interactions (C.A. Scott – PI, R. Varady – co-PI). \$10,000, Arizona Water Institute.

2007. Rural and environmental water gradients under rapid urban expansion in water-scarce basins (C.A. Scott – PI). \$5117,000, International Water Management Institute.

2008-12. Optimization of Dual Conjunctive Water Supply and Reuse Systems with Distributed Treatment for High-Growth Water-Scarce Regions (K. Lansey – PI; Lansey, R. Arnold, G. Bayraksan, C. Choi, C.A. Scott co-PIs). \$1,999,558 (plus \$30,725 supplement), National Science Foundation, Resilient and Sustainable Infrastructures (RESIN).

2008-10.2008. United States – Mexico transboundary aquifer assessment program (S. Megdal – PI, C.A. Scott, J. Callegary – co-PIs). \$333,333167,000, United States Geological Survey.

2008. Border-area climate change impacts and water sector adaptation workshop (G. Garfin - PI). \$13,000, California Department of Water Resources.

2008-09. Water and energy sustainability with rapid growth in the Arizona-Sonora border region (C.A. Scott – PI, M. Pasqualetti – co-PI). \$50,000, Arizona Water Institute.

2008-09. Climate-related water constraints and their implications for relations across international boundaries: The North American experience. The Climate and Hydrology Academic Network for Governance and the Environment (CHANGE). (G. Garfin - PI, V. Magana, R. Stewart - co-PIs). \$10,300 Embassy of Canada; \$5,000 NIDIS; \$3,000 Drought Research Initiative (Canada); \$7,000 Agriculture and Agri-Food Canada; \$3,000 Instituto Nacional de Ecología (Mexico) 11.

2008. Travel funding for two graduate student research assistants (J. McEvoy and A. Coles) to attend the joint International American Institute (IAI) – National Center Atmospheric Research (NCAR) colloquium on Seasonality and Water Resources in the Western Hemisphere in Mendoza, Argentina (10/06/08-10/17/08) (\$3,000/participant). Total award: \$6,000.

2008. The Foro Climatico Regional (Regional Climate Forum) for Northwest Mexico and the Southwest United States, April 10-11, at CICESE, Ensenada, Baja California. The Forum included participants from Mexico and the U.S. The Forum leveraged funds from the SARP project and contributed to building collaboration between U.S. and Mexican scientists in the region, and also contributed to the summer

2009. Water reuse to offset growth-driven water scarcity in the southwest: From supply augmentation to substitution (C.A. Scott – PI; R. Varady, A. Browning-Aiken – co-PIs). Award amount: \$74,789. WaterReuse Foundation.

2009. In-kind contribution from University of Arizona's Institute for the Study of Planet Earth (ISPE). \$3,000 for staff time and graphic production of the Binational Climate Summary. (G. Garfin)

2009. In-kind contribution from University of Arizona's Institute for the Study of Planet Earth (ISPE). \$1,400 for staff time for the contributions towards the production of the 2009 Border Governors Conference planning and final report.

2010. Travel funding for one graduate student research assistant (J. McEvoy) to present a paper at the Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS) Workshop, University of Illinois Champaign-Urbana (02/10). Total award: \$800.

2010. Pre-dissertation research award from University of Arizona's Social and Behavioral Science Research Institute for one graduate student research assistant (J. McEvoy) to continue related research on urban water vulnerability in Baja California (03/10). Total award: \$600.

2010. Pre-dissertation research award from University of Arizona's SBSRI Dissertation Development Award for one graduate student research assistant (J. McEvoy) to continue related research on urban water vulnerability in Baja California (04/10). Total award: \$1,000

2010. Student fellowship awarded from the University of Arizona's Water Sustainability Program to one graduate student research assistant (J. McEvoy) to continue related research on water vulnerability in northwestern Mexico. Total award: \$18,500